

Density Related Development in *Andraca bipunctata* (Walker) (Lepidoptera, Bombycidae)

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Density affects the dynamics of animal growth and populations through a process of self-regulation (Chitty 1957). The functional relationship between density and development has been studied in several insects (Beaver 1973; Klomp 1966; Henneberry and Kishaba 1966; Gruys 1970) but not in any tropical species. This paper quantitates the effects of varying density levels of larval instars and fecunds of *Andraca bipunctata* (Walker) on its growth rate. Aspects of the biology of this moth are discussed elsewhere (Banerjee 1970, 1971, 1979).

MATERIALS AND METHODS

Field collected moths were kept in the insectaries under natural fluctuations of light, temperature and humidity. Some of these moths mated and laid eggs. The larvae, pupae and moths that sequentially emerged from these eggs were used in the experiments on density effects.

Moths were kept in densities of 5, 10, 15, 20 and 25 pairs (1: 1 sex ratio) in insectary jars (diameter 30 cm.; height 40 cm.) and the total number of eggs laid by these pairs during an oviposition period of seven days was recorded. Sex wise survival of these moths was noted at intervals of seven and fifteen days.

First to fifth instar larvae and pupae were reared separately in groups of 10, 20, 30, 40 and 50 in insectary jars mentioned earlier on tea leaves provided as food. Larvae and pupae in these containers were examined every third day to record growth, and mortality until 95% of the population could be accounted for. The three day sampling period was decided from a knowledge of the life cycle of the moth. In evaluating density effects of fifth instar larvae, larval duration as well as the weights of pupae that emerged at various larval densities were recorded, while those for pupae, eclosion and sex of moths were recorded.

Each experiment had five replications with a control series having a single larva, pupa or moth depending on the nature of the experiment: all the replicates could not be run simultaneously. Experiments were conducted at room temperature varying between 23°C and 26°C under natural conditions of light.

RESULTS

1. Oviposition

In Table 1 the number of eggs laid at different density levels of the months during an oviposition period of seven days is shown. Although the variability due to individual oviposition within the group and mating effect could not be studied, average oviposition in the groups was definitely lower than that of single (control) pair. Increase in density led to a steady decline in the total and average numbers of eggs, except

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at density level of 25, when oviposition was slightly higher than at 20 pair level: this possibly reflects more of individual variation rather than reversal of group effect. In general, low densities were conducive to high rate of oviposition. Thus during the seven day period, oviposition at density level of 25 pairs was 61% lesser than that at single pair level.

Table 1. Fecundity of *Andraca bipunctata* Walker at different density levels with 1 : 1 sex ratio.

Density level (pairs of moths)	Total number of eggs laid in seven days	Average oviposition per day per female
1	500	71.43
5	1754	50.11
10	3896	55.65
15	4832	46.00
20	5432	38.80
25	7644	43.68

2 Adult survivorship

Survivorship of the male and female moths at various density levels with 1 : 1 sex ratio is shown in Table 2. Moth survival declined with increase in the density, and at all densities, females survived slightly longer than that of males possibly to complete oviposition. Moth survival also declined with time because by the second week, i.e. on the 15th day after starting the experiment, there was on an average a 50% reduction in population at all density levels. Survivorship may therefore depend on an interaction between density level and time.

Table 2. Survivorship of the adult moths of *Andraca bipunctata* Walker at different density levels with 1 : 1 sex ratio.

Density level (pairs of moth)	Numbers surviving on:					
	Seventh day			Fifteenth day		
	Male	Female	Percentage of total moth surviving	Male	Female	Percentage of total moth surviving
10	4	4	80	3	2	50
20	6	9	75	4	3	55
30	9	11	66	7	8	50
40	13	17	75	10	12	55
50	16	18	68	11	14	50

3. Duration of larval development

A measure of the density effect on larval duration may be obtained from the relationship:

$$\text{Density effect} = \frac{\text{Mean duration of grouped larvae}}{\text{Mean duration of single larva}}$$

The ratio computed for different larval instars at various density levels is shown in Figure 1. A ratio of <1.00 indicates no difference in the duration of the developmental stages maintained either in groups or singly, i.e. no density effect whereas >1.00 shows a definite density effect. The effect was significant, though varying, at all density levels and on all developmental stages. At all density levels the effect was most marked on fourth larval instar and least on first larval instars, i.e. the ratio increased.

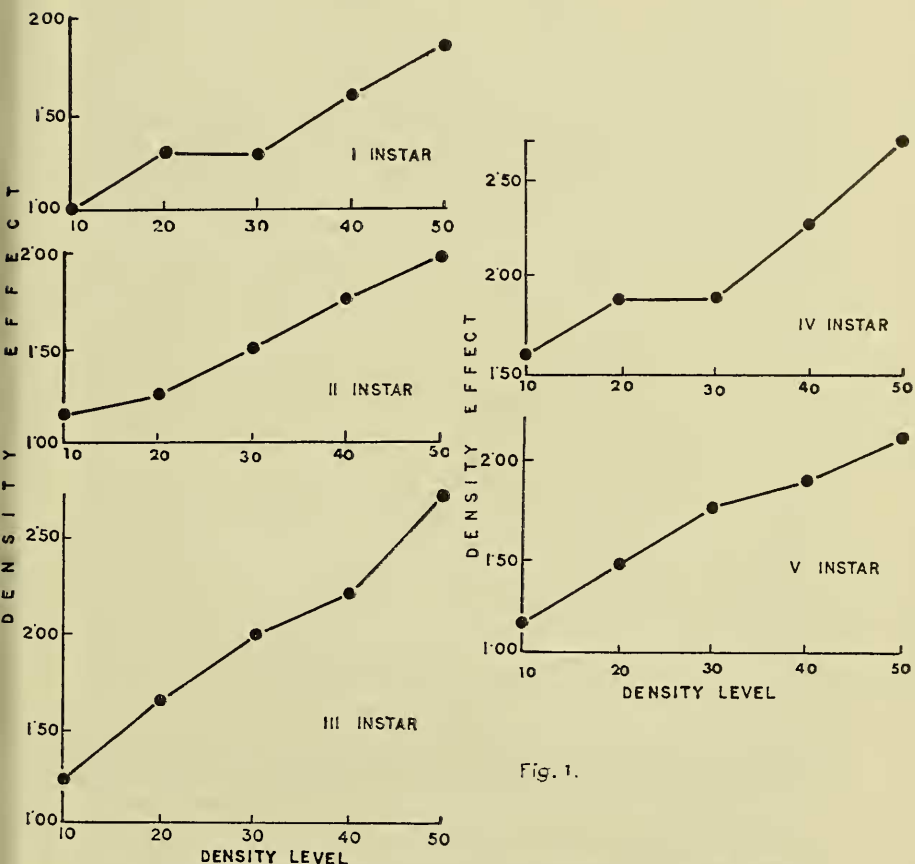


Fig. 1.

Fig. 1. Effect of larval density levels on the duration of larval stages of *Andraca bipunctata* Walker. Density effect is computed as the ratio of means duration of grouped larvae to mean of single larva.

Density levels did not however have any specific effect on larval mortality: the mounting successes in the succeeding larval instars were almost identical at all density levels (Table 3). There was an overall decline in moulting as development progressed but the trend was identical at various density levels.

4. Pupal weight, eclosion and sex ratio

Density levels of fifth larval instars affected the weight of the pupae that emerged in the groups. The ratio of mean group

Table 3. Effect of density on the percentage of moulting by larval instars of *Andraca bipunctata* Walker. Figures shown are the percentage of successful moulting from one larval instar to the next and are not continuous series.

Instar	10	20	30	40	50
Larval density					
Instar 1	95	96	80	83	75
Instar 2	85	87	75	75	70
Instar 3	90	95	80	75	68
Instar 4	80	82	77	75	70
Instar 5	75	70	70	65	57

weight, i.e. weight of pupae reared at various density levels of fifth instars to individual weight decreased linearly with larval density, and at 50 density level the average weight of the pupae was nearly half of that at 10 density level (Figure 2). The correlation between density and weight was highly significant ($\pi = -0.98$; $P < 0.01$).

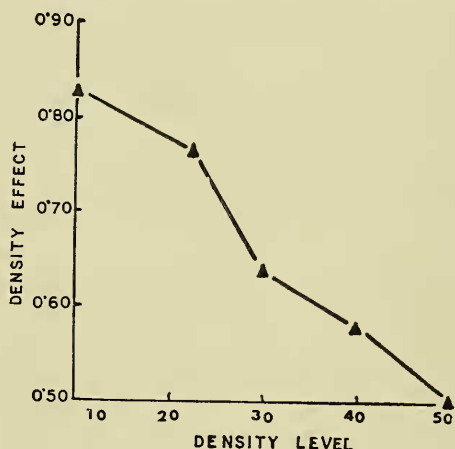


Fig. 2. Effect of densities of fifth larval instars of *Andraca bipunctata* Walker on pupal weight. Density effect is measured as the ratio of mean pupal weight to weight of single pupa. Weight of single pupa is about 240 mg.

Pupae kept at various density levels were followed to the emergence of moths. By and large, the percentage of eclosion was nearly the same at various density levels of the pupae and the sex ratio of the emerged moths did not vary significantly from an expected 1 : 1 sex ratio (Table 4).

DISCUSSION

Mutual interference resulting from high populations in restricted space affects growth, fecundity and pupal weight of lepidopterans (Ullyett 1950; Harrison 1964; Gruys 1970). In *Andraca bipunctata* rising larval densities prolonged duration of the larval stages, and reduced pupal weight, without causing a significant density related mortality at any stage. How-

Table 4. Effect of pupal densities on percentage of eclosion and sex ratio in *Andraca bipunctata* Walker.

Pupal density	Percentage of moth emergence	Average numbers of	
		Male	Female
10	94	4	5
20	93	9	9
30	95	15	13
40	92	18	18
50	92	22	24

ever, in some insects population level above a threshold caused a density related mortality (Stenhaus 1958; Doane 1960), but in *A. bipunctata* this did not become functional possibly because of three reasons. First, in all experiments food supply was adequate for the larvae thus eliminating a source of mortality; second, the containers were regularly cleaned to avoid any bacterial or other contamination that normally causes mortality; third, the level of population was possibly not high enough to induce competition which ultimately causes mortality. A reduction in fecundity and longevity with increase in density, on the other hand, suggests chances of adult survival and reproduction decreases with density. Therefore density above a level will not have any selective advantage for the population.

A differential response to increasing density levels is thus shown by the developing stages of *Andraca bipunctata*. Being inactive the pupae do not react in any way to density levels. In all cases density beyond a threshold has a negative effect on the developmental rates of larval instars and adult fecundity of *Andraca bipunctata*. If the effect is genetic, it could form a basis for selection (Gruys 1970), so that to avoid possible consequence like depletion of resources and consequent density related mortality, field populations of *Andraca bipunctata* will not become dense enough at any site for competition to become functional. This does not however preclude possibilities of a density related mortality from natural enemies which may have a regulatory effect on the populations of *Andraca bipunctata* (Banerjee 1979).

ABSTRACT

Oviposition and longevity of *Andraca bipunctata* Walker decrease with increase in moth density. Duration of each larval instar increases but pupal weight proportionally decreases with the increase in larval density. Eclosion rate and sex ratio of moths are not affected at different pupal densities. Differential responses of the developing stages of the insect to varying density levels suggest density above a threshold has no selective advantage for the species.

ACKNOWLEDGEMENT

I thank Director, Tocklai Experimental Station for his

interest, and Tea Research Association for permission to publish this report.

References

- Banerjee, B., 1970. Aggregating behaviour of the caterpillars of *Andraca bipunctata* Wlk. (Bombycidae: Lepidoptera). *Sci. & Cult.*, **36**: 236-238.
- Banerjee, B., 1971. Eclosion and oviposition rhythms of *Andraca bipunctata* Walker with a model for determining theoretical moth densities from eclosion rate. *Ind. J. Ent.*, **33**: 411-418.
- Banerjee, B., 1979. A key-factor analysis of of population fluctuations in *Andraca bipunctata* Walker (Lepidoptera: Bombycidae. *Bull. ent. Res.*, **69** (in press).
- Beaver, R. A., 1973. The effect of larval competition on puparial size in *Sarcophagus* spp. *J. Ent. (A)*, **48**: 1-9.
- Chitty, D., 1957. Self-regulation of numbers through changes in viability. *Cold Spring Harbour Symposia on Quantitative Biology*, **22**: 277-280.
- Doane, C. C., 1960. Bacterial pathogens of *Scolytus multistratus* Marsham as related to crowding. *J. Insect. Pathol.*, **2**: 24-29.
- Gruys, P., 1970. Mutual interference in *Bupalus piniarius* (Lepidoptera: Geometridae). *Proc. Adv. Study Inst. Dynamics Numbers Popul.* (Oosterbeck 1970): 199-207.
- Harrison, J. O., 1964. Factors affecting the abundance of lepidoptera in banana plantations. *Ecology*, **45**: 508-519.
- Henneberry, T. J., and Kishaba, A. N., 1966. Pupal size and mortality, longevity and reproductions of cabbage loopers reared at several densities. *J. Econ. Ent.*, **59**: 1490-1493.
- Klomp, H., 1966. The dynamics of a field population of the pine looper, *Bupalus piniarius* L. (Lep., Geom.). *Adv. ecol. Res.*, **3**: 207-305.
- Steinhaus, E. A., 1958. Crowding as a possible stress factor in insect disease. *Ecology*, **39**: 503-514.
- Ulyett, G. C., 1950. Competition for food and allied phenomena in sheep blowfly populations. *Trans. Royal. Soc. Lond.*, **B**: 234: 77-174.

EMUS HIRTUS LINNAEUS (COL.: STAPHYLINIDAE) AT CANTERBURY IN 1950. — In a collection of Coleoptera taken in the Old Park at Canterbury in May 1950, there is a specimen of the very rare *Emus hirtus* L. which was caught in a jar of meat bait set for *Necrophorus* and other carrion species. This impressive rove beetle is usually taken on or in fresh cowdung, but it is well known that predators are attracted to that medium not so much for the soup as for the maggots it contains, and so its occurrence in carrion is not surprising. This species has been recorded so rarely that this instance should perhaps not go unnoted, particularly in view of the different habitat. — JOHN PARRY, 38 Heather Drive, St. Michaels, Tenterden, Kent.

NOTICE

As we go to press, we hear of the sad news of the death on 10th May, of Dr. H. B. D. Kettlewell. An obituary notice will appear in due course.